

# PCT

## INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY (Chapter II of the Patent Cooperation Treaty)

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference NM 5232-01WO		FOR FURTHER ACTION See Form PCT/IPEA/416	
International application No. PCT/IB 2002/002775	International filing date (day/month/year) 15.07.2002	Priority date (day/month/year) --	
International Patent Classification (IPC) or national classification and IPC H04L 27/36, H04L 25/03			
Applicant Nokia Corporation et al			

1. This report is the international preliminary examination report, established by this International Preliminary Examining Authority under Article 35 and transmitted to the applicant according to Article 36.

2. This REPORT consists of a total of 4 sheets, including this cover sheet.

3. This report is also accompanied by ANNEXES, comprising:

a. ☒ (sent to the applicant and to the International Bureau) a total of 3 sheets, as follows:

☐ sheets of the description, claims and/or drawings which have been amended and are the basis of this report and/or sheets containing rectifications authorized by this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions).

☐ sheets which supersede earlier sheets, but which this Authority considers contain an amendment that goes beyond the disclosure in the international application as filed, as indicated in item 4 of Box No. I and the Supplemental Box.

b. ☐ (sent to the International Bureau only) a total of (indicate type and number of electronic carrier(s)) \_\_\_\_\_, containing a sequence listing and/or tables related thereto, in computer readable form only, as indicated in the Supplemental Box Relating to Sequence Listing (see Section 802 of the Administrative Instructions).

4. This report contains indications relating to the following items:

<input checked="" type="checkbox"/>	Box No. I	Basis of the report
<input type="checkbox"/>	Box No. II	Priority
<input type="checkbox"/>	Box No. III	Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
<input type="checkbox"/>	Box No. IV	Lack of unity of invention
<input checked="" type="checkbox"/>	Box No. V	Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
<input type="checkbox"/>	Box No. VI	Certain documents cited
<input type="checkbox"/>	Box No. VII	Certain defects in the international application
<input type="checkbox"/>	Box No. VIII	Certain observations on the international application

Date of submission of the demand  14.01.2004	Date of completion of this report  14.10.2004
Name and mailing address of the IPEA/SE Patent- och registreringsverket Box 5055 S-102 42 STOCKHOLM Facsimile No. +46 8 667 72 88	Authorized officer  Peder Gjervaldsaeter/ELY Telephone No. +46 8 782 25 00

## INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY

International application No.

PCT/IB 2002/002775

## Box No. I Basis of the report

1. With regard to the **language**, this report is based on the international application in the language in which it was filed, unless otherwise indicated under this item.

☐ This report is based on a translation from the original language into the following language \_\_\_\_\_, which is the language of a translation furnished for the purposes of:

- ☐ international search (under Rules 12.3 and 23.1(b))  
☐ publication of the international application (under Rule 12.4)  
☐ international preliminary examination (under Rules 55.2 and/or 55.3)

2. With regard to the **elements** of the international application, this report is based on *(replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report)*:

☐ the international application as originally filed/furnished

☒ the description:

pages 1 - 10 as originally filed/furnished

pages\* \_\_\_\_\_ received by this Authority on \_\_\_\_\_

pages\* \_\_\_\_\_ received by this Authority on \_\_\_\_\_

☐ the claims:

pages \_\_\_\_\_ as originally filed/furnished

pages\* \_\_\_\_\_ as amended (together with any statement) under Article 19

pages\* 1 - 3 received by this Authority on 2004-06-01

pages\* \_\_\_\_\_ received by this Authority on \_\_\_\_\_

☒ the drawings:

pages 1 - 3 as originally filed/furnished

pages\* \_\_\_\_\_ received by this Authority on \_\_\_\_\_

pages\* \_\_\_\_\_ received by this Authority on \_\_\_\_\_

☐ a sequence listing and/or any related table(s) – see Supplemental Box Relating to Sequence Listing.

3. ☐ The amendments have resulted in the cancellation of:

☐ the description, pages \_\_\_\_\_

☐ the claims, Nos. \_\_\_\_\_

☐ the drawings, sheets/figs \_\_\_\_\_

☐ the sequence listing (*specify*): \_\_\_\_\_

☐ any table(s) related to the sequence listing (*specify*): \_\_\_\_\_

4. ☐ This report has been established as if (some of) the amendments annexed to this report and listed below had not been made, since they have been considered to go beyond the disclosure as filed, as indicated in the Supplemental Box (Rule 70.2(c)).

☐ the description, pages \_\_\_\_\_

☐ the claims, Nos. \_\_\_\_\_

☐ the drawings, sheets/figs \_\_\_\_\_

☐ the sequence listing (*specify*): \_\_\_\_\_

☐ any table(s) related to the sequence listing (*specify*): \_\_\_\_\_

\* If item 4 applies, some or all of those sheets may be marked "superseded."

## INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY

International application No.

PCT/IB 2002/002775

**Box No. V** Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

## 1. Statement

Novelty (N)	Claims	<u>1-15</u>	YES
	Claims		NO
Inventive step (IS)	Claims	<u>1-15</u>	YES
	Claims		NO
Industrial applicability (IA)	Claims	<u>1-15</u>	YES
	Claims		NO

## 2. Citations and explanations (Rule 70.7)

**Prior art**

Reference is made to the following documents:

D1: Widrow et al: "Adaptive signal processing"

D2: WO 9 859 471

D3: Saleh et al: "Adaptive linearization of power amplifiers in digital radio systems"

D4: Bermudez et al: "Stability of non-Wiener solutions of the filtered LMS algorithm"

D5: US 6 285 412

D1 describes the use of the LMS algorithm in adaptive signal processing. It is described in D1 that the algorithm can be used to control plant noise. (See figure 11.25(b) and 11.26.)

D2 describes adaptive compensation in the transmitter for compensating for e.g. imperfect filters in the transmitter using the LMS algorithm. In D2 an error signal is obtained by subtracting an actual output signal from a desired output signal. This error signal and a signal corresponding to the actual output signal are then used in the adaptive algorithm. The adaption algorithm uses an instantaneous gradient estimate of a cost function. (See figure 6 and page 8, lines 16-28.)

D3 describes adaptive linearization of power amplifiers in digital radio systems.

D4 describes the filtered LMS algorithm, in which filtering is modelled by delays. (See figure 1.)

.../...

**Supplemental Box**

In case the space in any of the preceding boxes is not sufficient.

Continuation of: Box V

Document D5 represents the prior art. The claimed invention is not considered to be anticipated by this document.

**Claimed invention**

The invention according to the description relates to adaptive pre-equalisation of a transmitter circuitry in an OFDM-transmitter. According to the invention, the equaliser coefficients are adapted based on an approximated gradient. The gradient is determined based on a difference signal and an approximation of the transmission characteristic of the transmitter circuitry. The difference signal is the difference between the output signal from the transmitter circuitry and the input signal of the pre-equalisation means.

**Statement of reasons**

The cited documents represent the general state of the art. The invention defined in new claims 1-15 is not disclosed by any of these documents.

The cited prior art does not give any indication that would lead a person skilled in the art to the claimed method of and apparatus for pre-equalising of transmission characteristics. Therefore, the claimed invention is not obvious to a person skilled in the art.

Accordingly, the invention defined in claims 1-15 is novel and is considered to involve an inventive step. The invention is industrially applicable.

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### Claims

1. A method of pre-equalizing a transmission characteristic of a signal processing circuitry (200), said method comprising the steps of:
  - a) obtaining a difference between an output signal of said signal processing circuitry (200) and an input signal of a pre-equalizing function (15);
  - b) approximating a gradient of said difference based on said obtained difference and an approximation of said transmission characteristic; and
  - c) updating control values of said pre-equalizing function (15) based on said approximated gradient.
2. A method according to claim 1, wherein said approximating step comprises the step of calculating an approximation of a least mean square gradient vector of said difference.
3. A method according to claim 2, wherein said gradient vector is calculated from a partial differential equation of a system cost function.
4. A method according to any one of the preceding claims, wherein said difference is obtained by comparing signal envelopes of said output and input signals.
5. A method according to claim 4, wherein said input signal is a digital signal and said output signal is an analog signal.
6. A method according to any one of the preceding claims, wherein said control values are coefficients of an adaptive digital filter.
7. A method according to any one of the preceding claims, wherein said transmission characteristic is approximated as a delay function.
8. A method according to claim 7, wherein the delay of said delay function corresponds to the position of the maximum analog filter peak of said transmission characteristic.

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9. A method according to claim 8, wherein said gradient vector is calculated using the following equation:

$$\nabla\{E\} = -2e[k] \cdot \underline{d}[k - \tau],$$

wherein

- 5  $\nabla\{E\}$  denotes said gradient vector,  
 $e[k]$  denotes said obtained difference, and  
 $\underline{d}[k - \tau]$  denotes a vector representation of said input signal assessed by said delay approximation of said transmission characteristic.

10. A method according to claim 9, wherein filter coefficients are updated in said updating step based on the following equation:

$$\underline{w}[k + 1] = \underline{w}[k] + \mu e[k] \cdot \underline{d}[k - \tau],$$

wherein

- $\underline{w}[k + 1]$  denotes a vector representation of updated filter coefficients,  
 $\underline{w}[k]$  denotes a vector representation of current filter coefficients, and  
 15  $\mu$  denotes a predetermined proportionality factor.

11. An apparatus for pre-equalizing a transmission characteristic of a signal processing circuitry (200), said apparatus comprising:
- 20 a) comparing means (71) for obtaining a difference between an output signal of said signal processing circuitry (200) and an input signal of a pre-equalizing means (15);
- b) approximation means (72) for approximating a gradient of said difference based on said obtained difference and an approximation of said transmission characteristic; and
- 25 c) updating means (72) for obtaining control values supplied to said pre-equalizing means (15), based on said approximated gradient.

12. An apparatus according to claim 11, wherein said comparing means (71) are arranged to compare said input and output signals based on their envelopes.

- 30 13. An apparatus according to claim 11 or 12, wherein said approximation means (72) is arranged to approximate said transmission characteristic as a delay function and to approximate said gradient by using a least mean square approximation function.

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14. An apparatus according to any one of claims 11 to 13, wherein said signal processing circuitry is a direct conversion or heterodyne transmitter architecture (200).
  15. An apparatus according to any one of claims 11 to 14, wherein said apparatus comprises a digital pre-equalizer means (15).
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